

IRRIGATION PERFORMANCE ON IRRIGATED LOTS IN THE JACARÉ-CURITUBA PUBLIC IRRIGATION PROJECT

Clayton Moura de Carvalho¹, Antenor de Oliveira Aguiar Netto², Manoel Valnir Júnior³,
Raimundo Rodrigues Gomes Filho⁴, Ariovaldo Antonio Tadeu Lucas⁵, Leonaria Luna Silva de
Carvalho⁶

ABSTRACT: Irrigation assessment is a crucial step in obtaining information related to water use efficiency, application losses, water distribution uniformity, actual system performance, and maintenance needs. This process can prevent problems such as poor uniformity and efficiency, resulting in more appropriate and acceptable application rates. In this context, an evaluation of irrigation systems was carried out on different lots of the Jacaré-Curituba Public Irrigation Project, located between the municipalities of Canindé de São Francisco and Poço Redondo, in the state of Sergipe. Flow and pressure data were collected at selected points, following the methodology proposed by Keller & Karmeli (1975). Based on the field data, the performance of the perimeter irrigation systems was evaluated using the Coefficient of Distribution Uniformity (CUD) and Water Application Efficiency (Ea). The irrigation situation at the Jacaré-Curituba Public Irrigation Project is concerning, as the UDC was rated only "reasonable," while the Water Application Efficiency was considered "unacceptable." Even with the use of a localized irrigation system, irrigators lack the technological knowledge necessary to operate the system efficiently, demonstrating a lack of concern for periodic evaluation and continuous performance monitoring.

KEYWORDS: Localized irrigation, Micro-sprinkling, Coefficient of Uniformity, Irrigated Agriculture.

¹ Doctor in Agricultural Engineering, PosDoc Scholarship Holder at FAPITEC/SE, Collaborating Professor at UFS, carvalho_cmc@yahoo.com.br

² Doctor in Agronomy, Professor at UFS, antenor.ufs@gmail.com

³ Doctor in Agricultural Engineering, Professor at IFCE Sobral, valnir@ifce.edu.br

⁴ Doctor in Agricultural Engineering, Professor at UFS, rrgomesfilho@hotmail.com

⁵ Doctor in Applied Ecology, Professor at UFS, aatlucas@academico.ufs.br

⁶ Master in Agricultural Engineering, UFC, leonarialuna@hotmail.com

DESEMPENHO DA IRRIGAÇÃO EM LOTES IRRIGADOS NO PROJETO PÚBLICO DE IRRIGAÇÃO JACARÉ-CURITUBA

RESUMO: A avaliação da irrigação é uma etapa crucial para obter informações relacionadas à eficiência no uso da água, às perdas durante a aplicação, à uniformidade na distribuição da água, ao funcionamento real do sistema e à necessidade de manutenção. Esse processo pode prevenir problemas como baixa uniformidade e eficiência, resultando em valores de aplicação mais adequados e aceitáveis. Neste contexto, foi realizada a avaliação dos sistemas de irrigação em diferentes lotes do Projeto Público de Irrigação Jacaré-Curituba, localizado entre os municípios de Canindé de São Francisco e Poço Redondo, no estado de Sergipe. Foram coletados dados de vazão e pressão em pontos selecionados, conforme a metodologia proposta por Keller & Karmeli (1975). A partir dos dados obtidos em campo, foi possível avaliar o desempenho dos sistemas de irrigação do perímetro, utilizando o Coeficiente de Uniformidade de Distribuição (CUD) e a Eficiência de Aplicação de Água (Ea). A situação da irrigação no Projeto Público de Irrigação Jacaré-Curituba é preocupante, pois o CUD foi classificado apenas como "razoável", enquanto a Eficiência de Aplicação de Água foi considerada "inaceitável". Mesmo com a utilização do sistema de irrigação localizada, os irrigantes não possuem o conhecimento tecnológico necessário para operar o sistema de forma eficiente, demonstrando uma falta de preocupação com a avaliação periódica e o monitoramento contínuo do desempenho.

PALAVRAS-CHAVE: Irrigação localizada, Microaspersão, Coeficiente de Uniformidade, Agricultura Irrigada.

INTRODUCTION

Parameters associated with good irrigation practices are crucial for the effective planning and operation of irrigation systems. For this reason, annual system maintenance and the assessment of water distribution uniformity are recommended, in order to verify system performance and correct potential discrepancies. The results from the water distribution uniformity test serve both as a tool for irrigation management and as a diagnostic indicator of system maintenance needs. Thus, water distribution uniformity should be regarded as a key informational parameter for evaluating the operational status and efficiency of the irrigation system (Calgaro & Braga, 2008).

Irrigation evaluation is a crucial step to obtain information related to water use efficiency, application losses, distribution uniformity, actual system performance (flow rate, pressure, water depth, clogging, etc.), and maintenance needs. This process can prevent issues such as low uniformity and efficiency, resulting in more appropriate and acceptable water application values (Carvalho et al., 2006; Mantovani et al., 2009; Valnir Júnior et al., 2011; Andrade et al., 2021; Silva et al., 2023).

The performance quality of a localized irrigation system is often evaluated based on the Distribution Uniformity Coefficient, which is the most commonly used indicator. This coefficient allows for a more detailed analysis of problems related to water distribution along the lateral line, offering a more rigorous approach to such issues (López et al., 1992; Frizzone & Dourado Neto, 2003; Araquam & Campeche, 2012; Carvalho et al., 2012).

Given the above, the objective of this study was to evaluate the performance of the irrigation system in different lots of the Jacaré-Curituba Public Irrigation Project, in order to determine the current state of irrigation practices at the site.

MATERIALS AND METHODS

The research was conducted in November 2024 at the Jacaré-Curituba Public Irrigation Project, located in the northwestern portion of the state of Sergipe, covering the municipalities of Canindé de São Francisco and Poço Redondo, within the semi-arid region of the Upper Sertão of Sergipe (Figure 1).

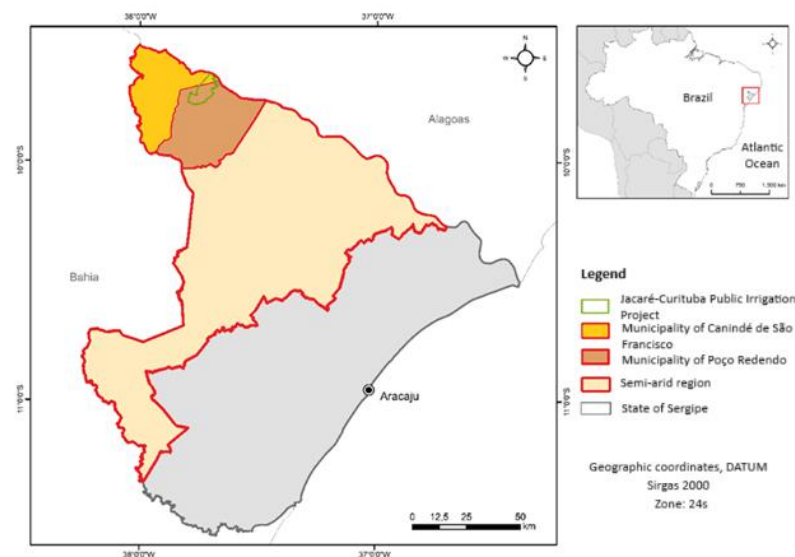


Figure 1. Location of the study area in the state of Sergipe, Brazil. Source: Lucas et al. (2021).

The total irrigated area of the project is 1,860 hectares, distributed across four sectors numbered from 0 to 3 (Figure 2). These sectors are designated for irrigation and livestock activities, comprising a total of 630 lots ranging in size from 2.5 to 3 hectares. It is the largest public irrigation project in Latin America focused on family farming, benefiting approximately 700 families. The predominant systems are localized irrigation, especially micro-sprinkler and drip irrigation. The main crops grown include okra, beans, corn, cassava, as well as fruits and vegetables in general (Meneses et al., 2015).

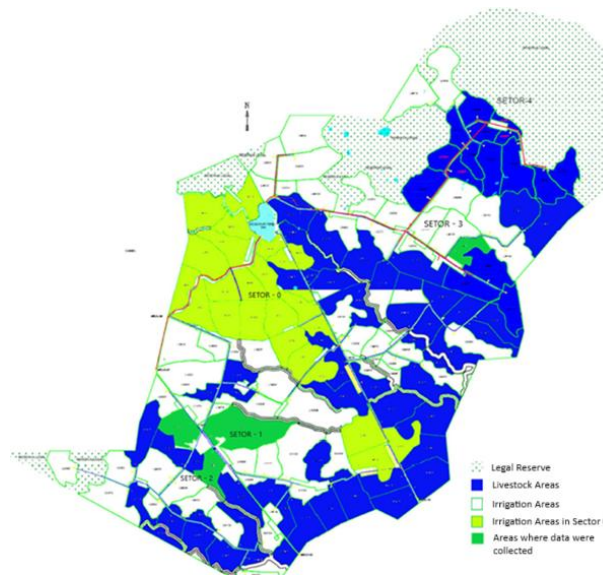


Figure 2. General Layout of the Jacaré-Curituba Public Irrigation Project.

Sixteen distinct lots were selected for the evaluation of the irrigation systems, all located within the Jacaré-Curituba Public Irrigation Project, belonging to different irrigators and showing no visible signs of soil salinization. The selection focused on lots located in sectors 1, 2, and 3, since sector 0, although irrigated, operates by gravity and does not rely on booster pumps for the operation of the irrigation systems.

For the field evaluations, a digital stopwatch and graduated cylinders with capacities of 500 mL and 1,000 mL were used to measure emitter flow rates. Operating pressures were determined using a glycerin-filled pressure gauge with a scale in kgf cm^{-2} , connected through appropriate fittings.

The analyses of the selected emitters were conducted according to the methodology proposed by Keller & Karmeli (1975) (Figure 3), with three repetitions in the collection of water volumes in order to obtain a representative average, with a duration of 30 seconds for each measurement. Then, using a spreadsheet developed by the author, the average flow rate in liters

per hour ($L h^{-1}$) was determined. Finally, the corresponding operating pressures for each evaluated micro-sprinkler were recorded.

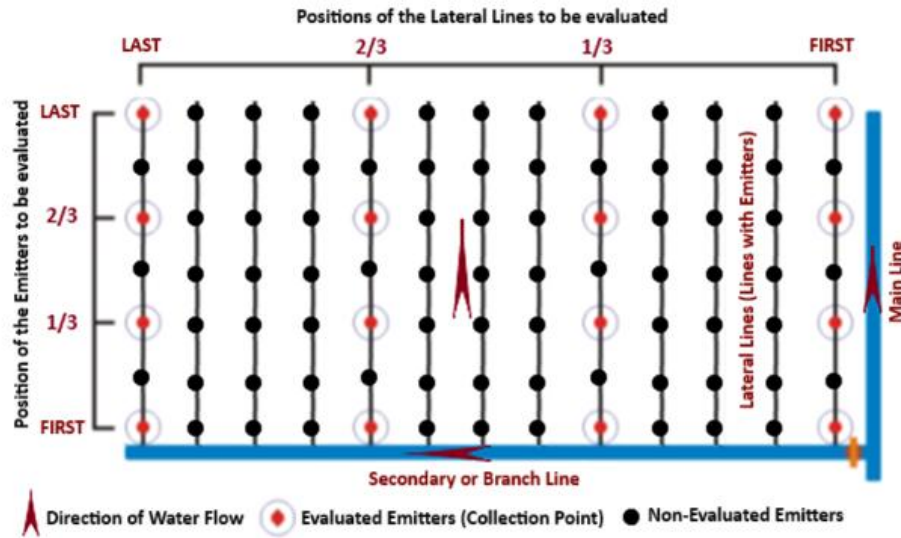


Figure 3. Layout of the collection point selection scheme according to the Keller & Karmeli (1975) methodology.

Based on the data obtained in the field, it was possible to evaluate the performance of the irrigation systems in the analyzed public project through the Distribution Uniformity Coefficient (CUD) and Water Application Efficiency (Ea), as expressed in equations 1 and 2.

$$CUD = \frac{Q_n}{Q_a} \times 100 \quad (1)$$

Where: CUD - Distribution Uniformity Coefficient in %; Q_n - average of the 25% lowest flow rates of the emitters in $L h^{-1}$; Q_a - average of the flow rates of all evaluated emitters in $L h^{-1}$.

$$Ea = K_s \times CUD \quad (2)$$

Where: Ea - Water application efficiency in %; K_s - transmissivity coefficient in decimal. For this study, a value of 0.90 (90%) was used, with the desirable K_s ranging from 85% to 90% according to Vermeiren & Jobling (1997).

The calculations of the Distribution Uniformity Coefficient and Water Application Efficiency were carried out with the help of a spreadsheet developed by the author. The classification of the irrigation system performance was established based on the criteria presented in Table 1.

Table 1. Classification of the performance values of localized irrigation systems based on the Distribution Uniformity Coefficient (CUD) and Application Efficiency (Ea).

Classification	CUD¹ (%)	Classification	Ea² (%)
Excellent	≥ 84	Ideal	> 95
Good	$68 \leq \text{CUD} < 84$	Acceptable	$80 \leq \text{Ea} < 95$
Fair	$52 \leq \text{CUD} < 68$	Unacceptable	< 80
Bad	$36 \leq \text{CUD} < 52$		
Unacceptable	< 36		

Source: ¹Mantovani et al. (2009); ²Bernardo et al. (2006).

RESULTS AND DISCUSSION

The results obtained for the Distribution Uniformity Coefficient (CUD) and Water Application Efficiency (Ea), along with their respective classifications, are presented in Table 2.

Table 2. CUD and Ea values with their respective classifications.

Lot	Q_{méd}	P_{méd}	%	CUD Classification¹	%	Ea Classification²
L ₁	42.56	81.40	72.60	Good	65.34	Unacceptable
L ₂	49.20	152.00	41.77	Bad	37.59	Unacceptable
L ₃	29.33	49.03	52.69	Fair	47.42	Unacceptable
L ₄	55.73	120.62	33.65	Unacceptable	30.28	Unacceptable
L ₅	27.45	40.21	8.20	Unacceptable	7.38	Unacceptable
L ₆	54.00	202.02	80.28	Good	72.25	Unacceptable
L ₇	42.90	118.66	80.77	Good	72.69	Unacceptable
L ₈ *	157.16	-	71.87	Good	64.68	Unacceptable
L ₉	50.29	102.97	51.30	Bad	46.17	Unacceptable
L ₁₀	49.50	195.15	87.88	Excellent	79.09	Unacceptable
L ₁₁	35.21	105.91	80.94	Good	72.84	Unacceptable
L ₁₂	29.93	86.30	0.00	Unacceptable	0.00	Unacceptable
L ₁₃	38.48	34.32	54.58	Fair	49.12	Unacceptable
L ₁₄	25.91	35.30	81.04	Good	72.94	Unacceptable
L ₁₅	46.20	101.01	11.36	Unacceptable	10.23	Unacceptable
L ₁₆	58.69	154.95	71.57	Good	64.41	Unacceptable
Average	49.53	105.32	55.03	Fair	49.53	Unacceptable

Lot - evaluated lots; Q_{méd} - average flow rate observed in the system (L h⁻¹); P_{méd} - average service pressure of the system (kPa); CUD - distribution uniformity coefficient (%); Ea - water application efficiency (%); ¹Mantovani et al. (2009); ²Bernardo et al. (2006); * Lot where it was not possible to measure the service pressure due to the diameter of the microtubing installed on the micro-sprinkler and the lack of a connection at the site..

The overall average balance of the evaluation of the localized irrigation systems in the Jacaré-Curituba Public Irrigation Project, in the state of Sergipe, indicated an acceptability level classified as 'fair' for the Distribution Uniformity Coefficient (CUD), with a value of 55.03%. On the other hand, the Water Application Efficiency (Ea), with an average of 49.53%, was

classified as 'unacceptable,' highlighting the inefficiency of the irrigation system implemented at the site.

Regarding the Distribution Uniformity Coefficient (CUD) values obtained in the Jacaré-Curituba Public Irrigation Project, 43.75% of the evaluated lots were classified as 'Good,' 25% received the classification 'Fair/Poor,' 25% were classified as 'Unacceptable,' and only 6.25% were rated as 'Excellent,' according to the classification proposed by Mantovani et al. (2009). Regarding Water Application Efficiency (Ea), all 16 evaluated lots (100%) were classified as 'Unacceptable,' according to the criteria established by Bernardo et al. (2006).

Meneses et al. (2015) observed that 50% of the evaluated lots were classified as 'Good/Excellent' for the Distribution Uniformity Coefficient (CUD), while 67.5% of the lots were applying water in an 'Unacceptable' manner. These results were attributed to possible leaks in the pipelines, emitter blockage, improper system sizing, and a low level of technological knowledge among the irrigators. Since these data were obtained in the same irrigated perimeter of this study, but with a decade of difference, it can be concluded that there has been no significant improvement in the irrigation systems. On the contrary, the results obtained currently indicate that the irrigation practices in the region have worsened, making it clearly unacceptable to maintain the system in its current conditions.

Maroufpoor et al. (2010), when evaluating the irrigation systems in ten farms located in the Dehgolan plain, in the Kurdistan province, northwest Iran, observed that the areas had an average Distribution Uniformity Coefficient (CUD) of 51%, which classifies the systems as having 'fair to poor' performance. Similarly, Zamaniyan et al. (2014) also reported that microirrigation systems in Iran show unsatisfactory performance, with the main identified causes being inadequate service pressure, emitter clogging, and the lack of proper training for the irrigators.

Contrasting results were observed by Araquam & Campeche (2012), who evaluated the water application uniformity in irrigation systems in the Nilo Coelho irrigated perimeter in Petrolina-PE. In this study, 90% of the lots irrigated by micro-sprinklers had Distribution Uniformity Coefficient (CUD) values classified as 'Good' or 'Excellent.' Similarly, Moura (2005), when evaluating areas located in the municipality of Paranapanema, in the southwest of São Paulo state, concluded that areas irrigated with micro-sprinkler systems showed good uniformity indices.

Farrapeira et al. (2023) concluded that the irrigation systems in twelve lots of the Poção da Ribeira Irrigated Perimeter exhibited excellent distribution uniformity and good water application efficiency, indicating that the systems were hydraulically well-designed. On the

other hand, Barreto Filho et al. (2000), when evaluating three subunits irrigated by micro-sprinklers in the São Gonçalo Irrigated Perimeter in the state of Paraíba, Brazil, observed that, despite the service pressure not being within the recommended parameters, the systems exhibited high uniformity coefficients and a good efficiency index.

CONCLUSIONS

The situation of irrigation in the Jacaré-Curituba Public Irrigation Project is alarming, as the Distribution Uniformity Coefficient was classified as 'fair' and the Water Application Efficiency as 'unacceptable.' Despite using the localized irrigation system, the irrigators lack the necessary technological knowledge to operate the system properly, showing no concern for periodic evaluation and continuous monitoring of its performance.

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